998,108

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in Turbine Engine and Gearbox Mounting Arrangement.

We, GENERAL ELECTRIC COMPANY, a corporation organised and existing under the laws of the State of New York, United States of America, of 1 River Road, Schenectady 5, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a turbine engine and gearbox mounting arrangement and in particular to a mounting arrangement for a shaft-driving turbine and gearbox assembly such as a turboprop engine.

As is well known in the art, the typical turboprop engine assembly includes a speed reduction gearbox associated with the engine for reducing the relatively high output speed of the engine to the lower speed required by the propeller. In some installations, the engine and the gearbox have been mounted essentially as separate elements in the airframe, the engine then being connected in driving relationship with the gearbox through a suitable flexible coupling designed to accommodate any misalignment that might occur. More recently, however, it has become a common practice to form the engine and its gearbox as a single assembly and then mount this assembly as a single unit in the airframe. This permits handling of the powerplant as a single element and it allows certain advantages in the way of factory assembly and adjustment which are more difficult to obtain where the engine and gearbox are mounted as separate units.

This approach does present certain problems, however, in that the gearbox must absorb a variety of loads in terms of propeller thrust and gyroscopic forces created by aircraft manoeuvers Where the gearbox and the engine are mounted as a single unit, there is a tendency for these loads to be transmitted back through the engine, placing bending moments on the engine structure and the interconnecting elements.

There are also difficulties presented by the possibility of a failure of one or more of the mounts or by failure of the connecting structure between the engine and the gearbox. Consider, for example, a three point suspension system in which two mounts are located on horizontally opposite sides of the gearbox and a third mount is located at the top or bottom of the engine about half way along its length. In this type of suspension, the engine mount will generally be selected to permit freedom of movement in the axial direction to allow for growth due to thermal expansion. The prior art also suggests that in this type of configuration, the engine may be secured to the gearbox by a torque tube enclosing the power output shaft and by two or more struts extending between the engine and the gearbox.

It will be observed that in such a configuration neither the engine nor the gearbox is capable individually of absorbing the full range of loads which are imposed because neither is mounted as a completely separate entity. Thus a failure in the interconnecting structure between the engine and the gearbox, to utilize this as an example, would leave the engine free to swing about its single mount, with the possibility of a catastrophic failure occurring as a result. One approach to this problem is to provide additional mounts on both the engine and the gearbox to make each essentially self-sustaining. With the engine and gearbox already tied together as a single entity, however, this leads to excessive redundancy in the mounting system, which imposes severe stresses on the engine

[*Price 4s. 6d.*]

and its mounting system on the occurrence of deflections in the airframe structure in which the engine and gearbox are mounted.

The object of this invention is to provide an improved engine and gearbox mounting arrangement which allows a single unit mounting arrangement and which provides protection against a failure in one or more of the mounts or in the interconnecting structure between the engine and the gearbox without imposing excessive loads on the engine as a result of airframe deflections, and which minimizes the bending moments imposed on the engine by propeller thrust and manoeuver loads.

In accordance with the invention, a mounting arrangement is provided for a turbine engine and gearbox assembly having at least two supporting struts extending between and connected with the engine and the gearbox as well as a torque tube enclosing the output drive shaft of the engine and rigidly interconnecting the turbine engine and the gearbox, a propeller shaft extending from the gearbox being offset from the axis of the engine output drive shaft, wherein first and second main mounts are circumferentially positioned on said gearbox on a plane extending between the offset axes of the output drive shaft and the propeller shaft, a third main mount positioned on said gearbox at a point intermediate the first and second main mounts, and wherein a fourth main mount is positioned on the turbine engine to provide flexibility of movement in the longitudinal direction to allow for thermal deflection. A pair of circumferentially positioned auxiliary mounts is further provided on the engine, the spring gradient characteristic of the auxiliary mounts relative to the main mounts being such to provide a relatively soft mount characteristic in the normal deflection range and to provide a hard mount characteristic in the deflection ranges of a magnitude representing a failure of one or more of the main mounts or of the torque tube.

In the accompanying drawings,

Fig. 1 is a side view of a shaft turbine engine assembly in accordance with the present invention;

Fig. 2 is a plan view of the shaft turbine engine assembly shown by Fig. 1; and

Fig. 3 is a rear view of the shaft turbine engine assembly shown by Fig. 1.

Fig. 4 is a graph to be described.

Referring to the drawings, a shaft turbine engine assembly 1 is shown having a gas turbine engine 2 as a power unit. The engine 2 has an outer engine casing 10 with annular members defined as a front frame 11 and a rear frame 12. A torque tube 3 encloses an output drive shaft, not shown, and rigidly interconnects the engine 2 of an offset gearbox 4. The offset gearbox 4 permits a relatively unobstructed air flow to an air inlet region 8 of the shaft turbine engine 2. The gearbox 4 has a propeller shaft 5 extending from the gearbox 4 to drive any desired unit; for example, a propeller not shown. Support struts 6 and 7 extend from the gearbox periphery 14 to the front frame 11 of the engine 2. More than two support struts may be provided if desired.

The mounting system of the present invention includes four resilient main mounts 15—18 in conjunction with two auxiliary mounts 19 and 20, shown in phantom by Fig. 2. The main mounts 15, 16, 17 and 18 can be classified as relatively "stiff" mounts, while the two auxiliary mounts 19 and 20 could be classified as relatively "soft" mounts, with a large change in spring gradient with increasing deflection which results in a "stiff" mount beyond certain normal deflections.

Mounts 15, 16 and 17 of the four main mounts 15—18 are circumferentially positioned on the gearbox periphery 14. The first main mount 15 and the second main mount 16 are generally located at peripheral points above the center line of the propeller shaft 5, and on either side of the center line of the torque tube 3. Thus, the two main mounts 15 and 16 will define a lateral plane intersecting a vertical plane developed through the center line of the propeller shaft 5 and the center line of the torque tube 3. This lateral plane will intersect the vertical plane at a point between the center line of the propeller shaft 5 and of the torque tube 3. The third main mount 17 of the four main mounts 15—18 is positioned on the gearbox periphery 14 at a circumferential point, between the first main mount 15 and the second main mount 16, which is diametrically opposed to a circumferential point on the gearbox periphery 14 adjacent to the torque tube 3.

The fourth main mount 18 is located on the rear frame 12 of the outer engine casing 10. This rear main mount 18 will provide vertical and lateral restraint of the shaft turbine engine assembly 1 in conjunction with the three main mounts 15—17 positioned on the gearbox periphery 14. However, the rear mount 18 is arranged so that it does not provide axial restraint of the engine assembly 1, since it is necessary to permit axial thermal growth of the engine 2 during operation. During normal operations of the shaft turbine engine assembly 1, the four main mounts 15—18 adequately support the assembly 1.

The mounting system further provides a first auxiliary mount 19 and a second auxiliary mount 20, shown in phantom by Fig. 2. The mounts 19 and 20 may be positioned on respective support rod attachment pads 25 and 26, also shown in phantom by Fig. 2.

The deflection characteristic of the

auxiliary mounts 19 and 20 is shown in Fig. 4. It will be observed that the spring gradient characteristic of these mounts is variable, providing a relatively soft mount in the smaller deflection range and a hard or stiff mount for the larger deflections.

The point A on the curve represents a deflection of a magnitude which would normally occur in the frequent maneuver range. In relation to the loads absorbed by the main mounts, the loads absorbed by the auxiliary mounts 19 and 20 for a deflection of this magnitude are virtually negligible. Point B represents a deflection in the infrequent manoeuver range, showing an increased contribution of the auxiliary mounts, but still not of sufficient magnitude to upset the overall load distribution pattern of the main mounting system. Point C represents a deflection of a magnitude occurring on failure of one of the main mounts, showing a material contribution of the auxiliary mounts, while point D represents a deflection of the magnitude which would occur upon a failure of the torque tube 3, a failure which would otherwise quite probably cause a catastrophic failure of the entire system. Over the range in the vicinity of point D, the auxiliary mounts act as hard or stiff mounts and perform a substantial support function, but in the ranges of points A and B do not produce any significant redundancy in the system. The stresses in the engine and mounting system which would otherwise be produced by airframe deflections in a fully redundant mounting system are thus avoided, while still retaining the advantages of redundancy for failures in the system.

The mounting system of the present invention for the shaft turbine engine assembly 1, referring now particularly to Fig. 1, provides compensation for various bending moments that may result from certain manoeuvers about the three major axes of the engine assembly 1 when mounted in an airframe or the like. These moments correlated to the manoeuvers would be a yawing moment about a vertical axis, a pitching moment about a lateral axis, and a rolling moment about an axial axis. The main mounts 15—17 on the gearbox periphery in conjunction with the main mount 18 on the rear frame 12 of the engine 2, reduce the rear mount loads since the three main mounts 15—17 of the present invention reduce a substantial portion of yawing gyroscopic loads in the axial direction.

The elastic center of the mounting system is shown at 50. The elastic center may be defined as the point in the system about which symmetrical load absorption on all mounts occurs. In the mounting arrangement disclosed, the elastic center 50 of the system is positioned as near as possible within practical design limits to the roll axis 40 such that roll deflections caused by propeller torque forces are symmetrically absorbed by the mounts, thus minimizing roll deflections. The roll axis is a line approximately parallel to the longitudinal axis of the engine about which the engine would rotate if disturbed.

The elastic axis of the three point gearbox suspension represented by the mounts 15, 16 and 17 is shown at 51. The elastic axis 51 of the three point gearbox mount is the axis along which an applied force will produce a symmetrical deflection of all three of the mounts, producing essentially a pure translation of the gearbox. The gearbox mounts 15, 16 and 17 are positioned about the propeller axis such that the elastic axis 51 falls closely adjacent to the axis of the propeller shaft 5 such that propeller thrust loads are absorbed symmetrically by the gearbox mounts. This minimizes bending forces which would otherwise be transmitted back through the torque tube 3 and the engine as a result of unsymmetrical deflection of the gearbox 4.

WHAT WE CLAIM IS:—

1. Mounting arrangement for a turbine engine and gearbox assembly having at least two supporting struts extending between and connected with the engine and the gearbox as well as a torque tube enclosing the output drive shaft of the engine and rigidly interconnecting the turbine engine and the gearbox, a propeller shaft extending from the gearbox being offset from the axis of the engine output drive shaft, wherein first and second main mounts are circumferentially positioned on said gearbox on a plane extending between the offset axes of the output drive shaft and the propeller shaft, a third main mount positioned on said gearbox at a point intermediate the first and second main mounts, and wherein a fourth main mount is positioned on the turbine engine to provide flexibility of movement in the longitudinal direction to allow for thermal deflection.

2. A mounting arrangement according to Claim 1, wherein a pair of circumferentially positioned auxiliary mounts is provided on the engine, the spring gradient characteristic of the auxiliary mounts relative to the main mounts being such to provide a relatively soft mount characteristic in the normal deflection range and to provide a hard mount characteristic in the deflection ranges of a magnitude representing a failure of one or more of the main mounts or of the torque tube.

3. Mounting arrangement according to Claim 1 or 2, wherein the elastic axis of the three main mounts on the gearbox is positioned adjacent to the axis of the propeller shaft.

4. Mounting arrangement according to any one of the foregoing claims, wherein the elastic center of the system formed by the four main mounts is positioned adjacent to the roll axis of the system.

5. Mounting arrangement as claimed in claim 1 substantially as described with reference to the accompanying drawings.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig 1

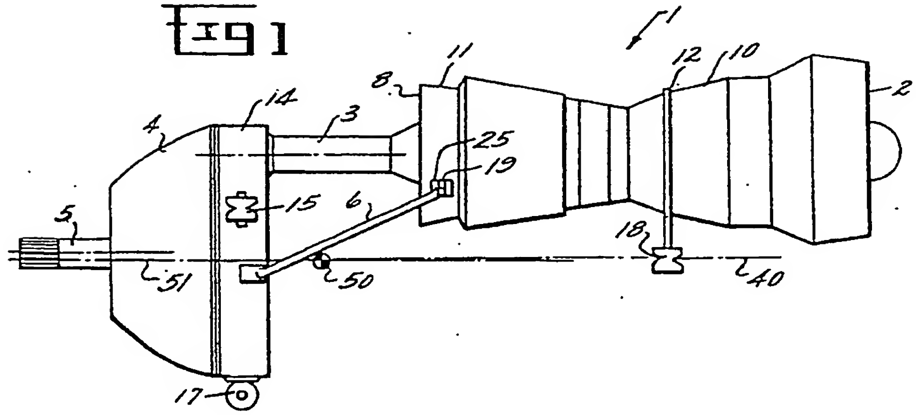

Fig 2

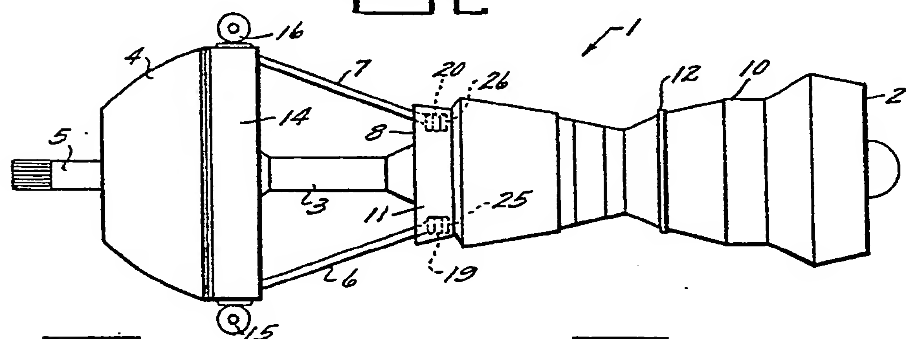

Fig 3

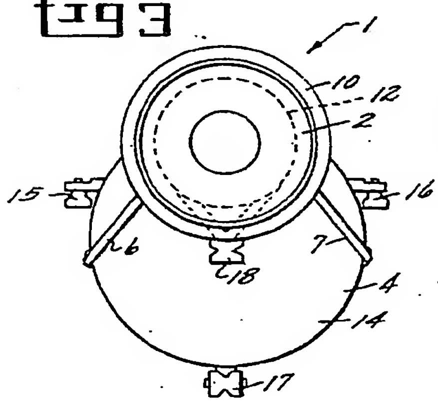

Fig 4